# Kingdom (biology)



The hierarchy of [biological classification](http://en.wikipedia.org/wiki/Biological_classification)'s eight major [taxonomic ranks](http://en.wikipedia.org/wiki/Taxonomic_rank). A [domain](http://en.wikipedia.org/wiki/Domain_%28biology%29) contains one or more kingdoms. Intermediate minor rankings are not shown.

In [biology](http://en.wikipedia.org/wiki/Biology), **kingdom** (Latin: ***regnum***, pl. ***regna***) is the second highest [taxonomic rank](http://en.wikipedia.org/wiki/Taxonomic_rank) below [domain](http://en.wikipedia.org/wiki/Domain_%28biology%29). Kingdoms are divided into smaller groups called [phyla](http://en.wikipedia.org/wiki/Phylum). Traditionally, textbooks from the [United States](http://en.wikipedia.org/wiki/United_States) used a system of six kingdoms ([Animalia](http://en.wikipedia.org/wiki/Animal), [Plantae](http://en.wikipedia.org/wiki/Plantae), [Fungi](http://en.wikipedia.org/wiki/Fungi), [Protista](http://en.wikipedia.org/wiki/Protista)/[protoctista](http://en.wikipedia.org/wiki/Protoctista),[Archaea](http://en.wikipedia.org/wiki/Archaea)\[Archaeabacteria](http://en.wikipedia.org/wiki/Archaeabacteria), and [Bacteria](http://en.wikipedia.org/wiki/Bacteria)\[eubacteria](http://en.wikipedia.org/wiki/Eubacteria) )while British, Australian and Latin American and others textbooks used five kingdoms (Animalia, Plantae, Fungi, [Protoctista](http://en.wikipedia.org/wiki/Protoctista), and [Prokaryota](http://en.wikipedia.org/wiki/Prokaryota)/[Monera](http://en.wikipedia.org/wiki/Monera)).

## Definition and associated terms

When [Carl Linnaeus](http://en.wikipedia.org/wiki/Carl_Linnaeus) introduced the rank-based system of [nomenclature](http://en.wikipedia.org/wiki/Nomenclature) into biology, the highest rank was given the name "kingdom" and was followed by four other main or principal ranks: the class, order, genus and species. Later two further main ranks were introduced, making the sequence kingdom, [phylum or division](http://en.wikipedia.org/wiki/Phylum), [class](http://en.wikipedia.org/wiki/Class_%28biology%29), [order](http://en.wikipedia.org/wiki/Order_%28biology%29), [family](http://en.wikipedia.org/wiki/Family_%28biology%29), [genus](http://en.wikipedia.org/wiki/Genus) and [species](http://en.wikipedia.org/wiki/Species). In the 1960s a rank was introduced above kingdom, namely [domain (or empire)](http://en.wikipedia.org/wiki/Domain_%28biology%29), so that kingdom is no longer the highest rank.

Prefixes can be added so [**subkingdom**](http://en.wikipedia.org/wiki/Subkingdom) and [**infrakingdom**](http://en.wikipedia.org/wiki/Infrakingdom) are the two ranks immediately below kingdom. Superkingdom may be considered as an equivalent of domain or empire or as an independent rank between kingdom and domain or subdomain. In some classification systems the additional rank **branch** (Latin: *ramus*) can be inserted between subkingdom and infrakingdom (e.g. [Protostomia](http://en.wikipedia.org/wiki/Protostomia) and [Deuterostomia](http://en.wikipedia.org/wiki/Deuterostomia) in the classification of Cavalier-Smith).

**Protozoa: Structure, Classification, Growth, and Development**

**Protozoa**

Protozoa are one-celled animals found worldwide in most habitats. Most species are free living, but all higher animals are infected with one or more species of protozoa. Infections range from asymptomatic to life threatening, depending on the species and strain of the parasite and the resistance of the host.

**Structure**

Protozoa are microscopic unicellular eukaryotes that have a relatively complex internal structure and carry out complex metabolic activities. Some protozoa have structures for propulsion or other types of movement.

**Life Cycle Stages**

The stages of parasitic protozoa that actively feed and multiply are frequently called trophozoites; in some protozoa, other terms are used for these stages. Cysts are stages with a protective membrane or thickened wall. Protozoan cysts that must survive outside the host usually have more resistant walls than cysts that form in tissues.

**Reproduction**

Binary fission, the most common form of reproduction, is asexual; multiple asexual division occurs in some forms. Both sexual and asexual reproduction occur in the Apicomplexa.

**Structure**

Protozoa are unicellular eukaryotes. As in all eukaryotes, the nucleus is enclosed in a membrane. In protozoa other than ciliates, the nucleus is vesicular, with scattered chromatin giving a diffuse appearance to the nucleus, all nuclei in the individual organism appear alike. One type of vesicular nucleus contains a more or less central body, called an endosome or karyosome. The endosome lacks DNA in the parasitic amebas and trypanosomes. In the phylum Apicomplexa, on the other hand, the vesicular nucleus has one or more nucleoli that contain DNA. The ciliates have both a micronucleus and macronucleus, which appear quite homogeneous in composition.

The organelles of protozoa have functions similar to the organs of higher animals. The plasma membrane enclosing the cytoplasm also covers the projecting locomotory structures such as pseudopodia, cilia, and flagella. The outer surface layer of some protozoa, termed a pellicle, is sufficiently rigid to maintain a distinctive shape, as in the trypanosomes and *Giardia*. However, these organisms can readily twist and bend when moving through their environment. In most protozoa the cytoplasm is differentiated into ectoplasm (the outer, transparent layer) and endoplasm (the inner layer containing organelles); the structure of the cytoplasm is most easily seen in species with projecting pseudopodia, such as the amebas. Some protozoa have a cytosome or cell “mouth” for ingesting fluids or solid particles. Contractile vacuoles for osmoregulation occur in some, such as *Naegleria* and *Balantidium*. Many protozoa have subpellicular microtubules; in the Apicomplexa, which have no external organelles for locomotion, these provide a means for slow movement. The trichomonads and trypanosomes have a distinctive undulating membrane between the body wall and a flagellum. Many other structures occur in parasitic protozoa, including the Golgi apparatus, mitochondria, lysosomes, food vacuoles, conoids in the Apicomplexa, and other specialized structures. Electron microscopy is essential to visualize the details of protozoal structure.

**Classification**

In 1985 the Society of Protozoologists published a taxonomic scheme that distributed the Protozoa into six phyla. Two of these phyla—the Sarcomastigophora and the Apicomplexa--contain the most important species causing human disease. This scheme is based on morphology as revealed by light, electron, and scanning microscopy.*Dientamoeba fragilis*, for example, had been thought to be an ameba and placed in the family Entamoebidae. However, internal structures seen by electron microscopy showed that it is properly placed in the order Trichomonadida of flagellate protozoa. In some instances, organisms that appear identical under the microscope have been assigned different species names on the basis of such criteria as geographic distribution and clinical manifestations; a good example is the genus *Leishmania*, for which subspecies names are often used. Biochemical methods have been employed on strains and species to determine isoenzyme patterns or to identify relevant nucleotide sequences in RNA, DNA, or both. Extensive studies have been made on the kinetoplast, a unique mitochondrion found in the hemoflagellates and other members of the order Kinetoplastida. The DNA associated with this organelle is of great interest. Cloning is widely used in taxonomic studies, for example to study differences in virulence or disease manifestations in isolates of a single species obtained from different hosts or geographic regions. Antibodies (particularly monoclonal antibodies) to known species or to specific antigens from a species are being employed to identify unknown isolates. Eventually, molecular taxonomy may prove to be a more reliable basis than morphology for protozoan taxonomy, but the microscope is still the most practical tool for identifying a protozoan parasite.

**Reproduction**

Reproduction in the Protozoa may be asexual, as in the amebas and flagellates that infect humans, or both asexual and sexual, as in the Apicomplexa of medical importance. The most common type of asexual multiplication is binary fission, in which the organelles are duplicated and the protozoan then divides into two complete organisms. Division is longitudinal in the flagellates and transverse in the ciliates; amebas have no apparent anterior-posterior axis. Endodyogeny is a form of asexual division seen in *Toxoplasma* and some related organisms. Two daughter cells form within the parent cell, which then ruptures, releasing the smaller progeny which grow to full size before repeating the process. In schizogony, a common form of asexual division in the Apicomplexa, the nucleus divides a number of times, and then the cytoplasm divides into smaller uninucleate merozoites. In *Plasmodium, Toxoplasma*, and other apicomplexans, the sexual cycle involves the production of gametes (gamogony), fertilization to form the zygote, encystation of the zygote to form an oocyst, and the formation of infective sporozoites (sporogony) within the oocyst.

Some protozoa have complex life cycles requiring two different host species; others require only a single host to complete the life cycle. A single infective protozoan entering a susceptible host has the potential to produce an immense population. However, reproduction is limited by events such as death of the host or by the host's defense mechanisms, which may either eliminate the parasite or balance parasite reproduction to yield a chronic infection.

**Nutrition**

The nutrition of all protozoa is holozoic; that is, they require organic materials, which may be particulate or in solution. Amebas engulf particulate food or droplets through a sort of temporary mouth, perform digestion and absorption in a food vacuole, and eject the waste substances. Many protozoa have a permanent mouth, the cytosome or micropore, through which ingested food passes to become enclosed in food vacuoles. Pinocytosis is a method of ingesting nutrient materials whereby fluid is drawn through small, temporary openings in the body wall. The ingested material becomes enclosed within a membrane to form a food vacuole.

Protozoa have metabolic pathways similar to those of higher animals and require the same types of organic and inorganic compounds. Research on the metabolism of parasites is of immediate interest because pathways that are essential for the parasite but not the host are potential targets for antiprotozoal compounds that would block that pathway but be safe for humans. Many antiprotozoal drugs were used empirically long before their mechanism of action was known. The sulfa drugs, which block folate synthesis in malaria parasites, are one example.

The rapid multiplication rate of many parasites increases the chances for mutation; hence, changes in virulence, drug susceptibility, and other characteristics may take place. Chloroquine resistance in *Plasmodium falciparum* and arsenic resistance in *Trypanosoma rhodesiense* are two examples.

Competition for nutrients is not usually an important factor in pathogenesis because the amounts utilized by parasitic protozoa are relatively small. Some parasites that inhabit the small intestine can significantly interfere with digestion and absorption and affect the nutritional status of the host; *Giardia* and *Cryptosporidium* are examples. The destruction of the host's cells and tissues as a result of the parasites' metabolic activities increases the host's nutritional needs. Finally, extracellular or intracellular parasites that destroy cells while feeding can lead to organ dysfunction and serious or life-threatening consequences.